

BAETODES: NEW SPECIES AND NEW RECORDS FOR NORTH AMERICA (EPHEMEROPTERA: BAETIDAE)¹

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Baetodes is an austral genus of mayflies primarily known from Central and South America. Only once has the genus been reported occurring in the United States, and this record was of a single nymph collected in Texas in 1936 (Edmunds, 1950). This paper describes two new species of *Baetodes* discovered in the southwestern United States. One species was found only in Oak Creek Canyon, Arizona, while the other is known from Arizona, New Mexico, and Texas (the record mentioned above).

The following suggestions are made in this paper in an effort to standardize terminology.

(1) Needham and Murphy (1924) noted the presence of "long brown spines" along the dorsal crest of the femora of *Baetodes* nymphs (Figs. 9, 21, 22). Spines are multicellular outgrowths of the body wall, are not separated from the wall by a joint, and are immovable. Setae—and the "long brown spines" of Needham and Murphy—are movable structures connected to the body via a joint or socket. Müller-Liebenau (1966) found parallel-sided and club-shaped (parallelseitiger, kuelenformig) structures of the same type on the femoral crests in *Baetis subalpinus* Bengtsson, and considered these structures to be setae (Borsten). I consider the robust structures ("long brown spines") along the dorsal crest of the femora in *Baetodes* nymphs (Figs. 9, 21, 22) to be setae, and propose that they be called "clavate setae."

(2) The structures along the ventral edge of the tibiae and tarsi (Fig. 20), and along the subapical and lateral margins of the labrum (Figs. 2, 14) are also not spines (Mayo, 1968; Traver & Edmunds, 1968) since they are likewise situated in a socket and articulate. Those on the legs may correctly be

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called "spurs," those on the labrum should be called "spine-like setae."

(3) The median "spines" of the terga (Fig. 12) should be called "tubercles" in order to be consistent with the terminology used by Allen & Edmunds (1965, and other parts cited therein) in the *Ephemerella* revisions.

Baetodes is poorly known in the adult stage. Until now, only the adults of *B. spiniferum* Traver (1943) have been described, and they are not positively known to be *Baetodes* since adult specimens have never been reared or otherwise associated with nymphs from the same locality. Traver justifiably determined the specimens to be *Baetodes* via a process of elimination and because of a similarity of certain adult features to known nymphal features. Reared adult *Baetodes* are now available, and it is important to note that the generic definition based on those specimens is not entirely compatible with the known features of *B. spiniferum*. The latter differs in ratios of leg segments and in degree of development of marginal intercalaries. Before the genus can be accurately characterized in the adult stage, it will be necessary to rear *Baetodes* in Central and South America.

Edmunds (1950) distinguished adult *Baetodes* (*B. spiniferum*) from *Pseudocloeon* by the length of the male fore tibia, which in the former was said to be more than twice the length of the femur, but less than twice the length in *Pseudocloeon*. In one of the *Baetodes* species described below (male imago unknown in other) the tibia:femur ratio is similar to that of *Pseudocloeon*, thereby negating the usefulness of this character for generic distinctions.

Wing morphology is useful in separating the two genera. Unlike *Baetodes* (see below), the entire hind margin of the *Pseudocloeon* wing is continuously curved, and the marginal intercalaries are well-developed and long from R_2 to CuP (see Jensen, 1969, for wing illustration).

GENUS *BAETODES* NEEDHAM AND MURPHY

Male characteristics are drawn from *B. edmundsi*, whereas female features are drawn from *B. edmundsi* and *B. arizonensis*.

Adult.—Marginal intercalaries in forewings (Figs. 1, 11) weak and short behind R_2 , absent in cubital area or at most very weakly developed in CuA interspace; each marginal intercalary barely as long as space between members of a pair, and rarely as long as space between the two bounding longitudinal veins. Stigmatic crossveins simple, slanting and ca. 5 in number. In basal 1/3 to 1/2 of wing, hind margin subparallel to costal margin; anal angle of wing strongly curved. Hind wings absent. Posterior margin of pronotum deeply emarginate; at least in male imagoes, metascutellum smooth or nearly so, not developed posteromedially as a prominent flattened hump. In leg I of male, tibia 1 1/2-1 2/3 the length of the femur (tibia 2 times length of femur in *B. spiniferum*); tarsus 1/2-2/3 as long as tibia; size arrangement of tarsal segments, in decreasing order: 2, 3, 4, 5, 1. In legs II and III of male and all legs of female, tibia 1-1 1/3 the length of femur,

tarsus 1/3-1/2 as long as tibia, and size arrangement of tarsal segments (Fig. 13), in decreasing order: 4, 1, 2, 3. In both sexes, tarsal segment 1 of legs II and III almost completely fused to tibia (Fig. 13), its point of contact evident only as a ventral notch; tarsal segment 1 in leg I not as completely fused to tibia in female, and not fused at all in male.

B. arizonensis and *B. edmundsi*, NYMPHS

B. arizonensis and *B. edmundsi* are described below. In addition to known generic characters (Edmunds, 1950; Mayo, 1968) nymphs of the two species have the following features in common.

Submatures lighter in overall coloration than matures, which may be very blackish-brown dorsally. Head brown, darker brown patches on frons, genae, and vertex. Apical margin of labrum (Figs. 2, 14) fringed with a closely set row of pectinate setae. Dorsal (anterior) surface of labrum with long, spine-like setae in a subapical, transverse row which continues basad along lateral margins. This arrangement is similar to labral spine Group I A (1) described by Traver and Edmunds (1968) for *Dactylobaetis* nymphs except that if any, 3 setae rather than 1 are centrally removed from the laterals (fig. 14). Intermediary spine-like setae ("intermediary spines" of Traver & Edmunds) also present (Fig. 14), and these are ca. 1/2 the length of subapicals; intermediaries mostly in basal region of labrum, occasionally near or in subapical row. Ventrally, each side of labrum with a sublateral row of spine-like setae similar in size to subapicals.

General thoracic color brown with darker brown markings. Pronotum light brown, anterior margin darkened by a broadly-based dark brown triangle; each submedian area with 2 irregular, longitudinal dark brown stripes. Mesonotum with a dark brown T-shaped mark covering anterior margin and anterior 1/2-3/4 of midline; an elongate triangular brown streak and several circular brown spots on each side of midline. Posterolateral corners of metanotum with elongate, needlelike remnants of hind wingpads. Fur-casternal pits brown.

Coxae brown. Anterior surface of femora brown with a white discal streak and proximal spot which may be coalesced, and a dark brown streak paralleling the femoral crest; posterior surface white. Coxae dorsolaterally expanded; crest of femora with a compact row of fine hairs immediately adjacent to row of clavate setae (Figs. 9, 21, 22), and a similar row of hairs along dorsal crests of coxae, tibiae and tarsi (Fig. 20); clavate setae mostly situated along proximal half of femoral crest and an additional 1 or 2, usually 2, clavate setae subapically on femora; sockets of subapical pair of setae adjacent or nearly so. Tarsi and distal 1/3-1/2 of tibiae with short, robust spurs along ventral surface (Fig. 20). Each tibia with a continuous longitudinal and transverse "break" or articulation on the anterior and ventral surfaces, respectively (Fig. 20), and these areas are membranous and allow limited flexing within the tibial segment. Such "articulations" may serve as "shock absorbers" to aid the nymphs in with-standing the fast currents to which they subject themselves by clinging to the top surfaces of rocks in midstream.

Body, including hind margin of head, with a longitudinal, middorsal row of erect hairs; most hairs about as long as an individual tergum (Figs. 8, 12). Hairs extend between the eyes along dorsal edge of head, are scattered over the median third of the thorax, and are restricted to the midline on the abdomen. Cerci pale ventrally, brown dorsally.

Baetodes arizonensis Koss, NEW SPECIES

(Figures 1-10)

Male Subimago.—Length: body 5 mm; forewing 5 mm. Head dark brown, a submedian pale streak near the base of each lateral ocellus. Thorax brown ventrally, dark brown dorsally. Coxae dark reddish-brown on anterior surface, pale to pale brown on posterior surface; remainder of legs pale brown to brown, darker brown along margins; anterior surface of femora usually with a central, longitudinal, reddish-brown streak. Size arrangement of tarsal segments in decreasing order, leg 1: 2, 3=5, 4, 1.

Terga 1-7 or 8 dark reddish-brown; tergum 9 brown to reddish-brown; tergum 10 brown. Sternum 1 pale, light reddish-brown stipling laterally. Sterna 2-9 pale posteromesally, anterior $1/4$ - $1/3$ of each segment dark reddish-brown, and in each anterolateral corner a somewhat triangular reddish-brown patch which extends nearly the full length of each segment; reddish-brown coloration diminishes in extent posteriorly and sometimes faint at midline. Caudal filaments and forceps pale brown. Inner apical margin of forceps segment 1 indistinct on specimens available, but blunt projection seems present.

Female imago.—Length: body 5 mm; forewing 6 mm (Fig. 1). Head brown, white surrounding each lateral ocelli and extending to meson. Pronotum patchy brown and pale. Mesonotum light brown to brown; scutum reddish-brown anteriorly and a longitudinal reddish-brown streak on each side of midline extending from anterior margin to middle of scutum. Metanotum brown as in mesonotum, but anterior half also with reddish-brown staining; metascutellum with a low, pointed posteromedian hump. Thoracic sterna brown laterally and anteriorly, pale elsewhere. Veins and crossveins brown.

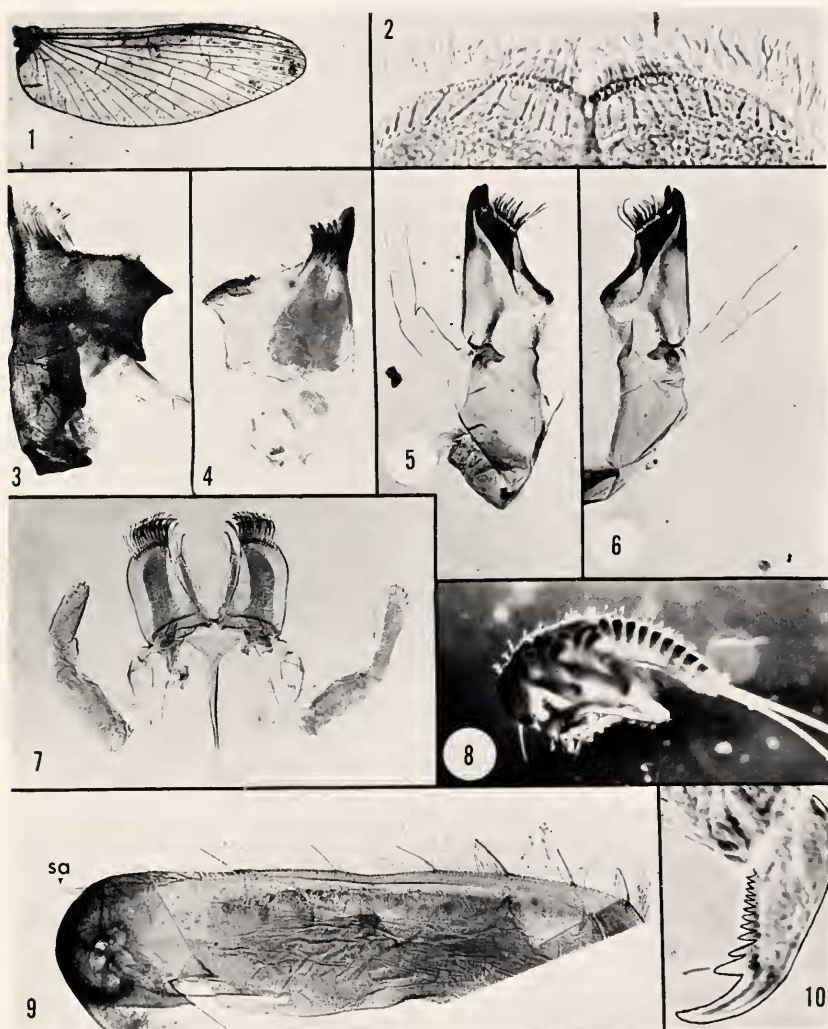
Legs pale, brown at joinings; anterior surface of femora with a central, longitudinal, reddish-brown streak. In legs I and II, tibia ca. $1\frac{1}{4}$ the length of femur; tarsus ca. $1/3$ as long as tibia. In leg III, tibia 1 - $1\frac{1}{4}$ as long as femur; tarsus $1/3$ - $1/2$ as long as tibia.

Terga 1-9 reddish-brown, posterior margin of 9 occasionally pale; tergum 10 pale brown with three dark spots—one at the base of each caudal filament and one anteromesally; disc and posterior margin of terga 2-6 variable, frequently pale over medial $1/5$ of segments 2 and 3, and medial $1/2$ of segments 4-6. Sternum as in male subimago. Caudal filaments pale brown to reddish-brown.

Female Subimago.—Coloration as in female imago.

Nymph.—Length, mature nymph: body 4.5-5.5 mm; cerci 6-7 mm. Mouthparts as in Figs. 2-7. Dorsally, labrum (Fig. 2) with 9-12 spine-like setae each side of midline, in transverse portion of subapical row; of these, usually 3 setae close to midline, 2 isolated centrally in each half of labrum, and remaining setae in a row extending to lateral margin; otherwise, all setae in transverse part of row more or less equidistantly spread. Sublateral margins of pronotum dark brown; posterior margin dark brown except mesally. Posterior margin of pro- and mesonota lacking a median tubercle (Fig. 8). Metanotum dark reddish-brown; a tubercle or at least a low median hump at posterior margin. Thoracic pleurae reddish-brown, pale on ventral margins; sterna white, lightly stipled with reddish-brown laterally. Dorsolateral expansions gradual and extending full length of segment on all coxae; coxal gills absent. Femoral disc usually with a light reddish-brown longitudinal streak; femoral crests usually with 3-7 clavate setae, only occasionally with 8 or more (14 have been observed on one femur); subapex of femora with an additional 1 or 2 clavate setae, usually 2 (Fig. 9). Tibiae and tarsi dark brown, lighter brown to white on posterior surfaces. Claws with 9-12 denticles (Fig. 10).

Terga 1-8 dark reddish-brown, frequently with small, variously shaped, medial and



Figures 1-10, *Bactodes arizonensis*, new species. Fig. 1, right forewing, female imago; Figures 2-10, nymphal structures. Fig. 2, apical margin of labrum; Fig. 3, left mandible; Fig. 4, right mandible; Fig. 5, left maxilla; Fig. 6, right maxilla; Fig. 7, labium; Fig. 8, lateral view of nymph; Fig. 9, femur, leg III (sa=subapical clavate setae); Fig. 10, claw.

submedial pale markings; tergum 9 variable, basal half or more dark reddish-brown; tergum 10 and remainder of 9 brown with some pale markings mesally. Terga 1-6 each with a low, blunt posteriorly-directed median tubercle; terga 7-9 with a very low median hump. Sterna 2-10 pale to yellow; anterior margin of sterna 2-9 reddish-brown, in each anterolateral corner a large reddish-brown triangle which extends the full length of most segments; reddish-brown coloration diminishes in extent posteriorly, and sometimes faint or lacking at midline.

Types. Holotype: male subimago, reared from nymph, Oak Creek, Banjo Bill Campgrounds, Oak Creek Canyon, so. of Flagstaff, Coconino Co., ARIZONA, collected 6/V/1969, emerged 11/V/1969, R. W. Koss and A. V. Provonsha, in collection of University of Utah (UU), Salt Lake City. *Allotype:* female imago, reared from nymph, same data and deposition as holotype. *Paratopotypes:* 3 male subimagoes, 4 female imagoes, 3 female subimagoes, all reared from nymphs, same data as holotype; 103 nymphs, 9/IV/1968, R. W. Koss and R. W. Baumann, other data as holotype; 56 nymphs, 5-6/V/1969, other data as holotype. Of these, 1 male subimago, 2 female imagoes, 2 female subimagoes, and 51 nymphs, UU collection; 2 male subimagoes, 2 female imagoes, 1 female subimago and 27 nymphs, R. W. Koss collection; and 9 nymphs in each of the following collections: British Museum (Natural History), London; California Academy of Sciences, San Francisco; California State College, Los Angeles; Florida A & M University, Tallahassee; Institute Royal des Sciences Naturelles, Brussels; V. K. Mayo, Tucson, Arizona; I. Müller-Liebenau, Max-Planck-Institut für Limnologie, Plön, Germany; Purdue University, Lafayette, Indiana; and United States National Museum, Washington.

Paratypes: 7 nymphs, Oak Creek, Encinosa Campground, Oak Creek Canyon, 4 mi. no. of Sedona, Coconino Co., ARIZONA, 8/IV/1970, G. F. & C. H. Edmunds, Jr., UU collection.

Baetodes edmundsi, Koss, NEW SPECIES³

(Figures 11-23)

Baetodes sp. Edmunds, 1950. Ent. News, 61:204.

Male imago.—Length: body 5 mm; forewings 5 mm (Fig. 11). Head brown, black at base of ocelli; antennae light brown. Dorsal surface of turbinate eyes ellipsoidal and orange; basal half of sides orange, apical half pale; eyes contiguous basally, divergent dorsally. Entire thorax brown except for membranous areas; veins C to MP₁ of wing light brown; crossveins and other longitudinal veins hyaline. Leg I brown; legs II and III pale, brown along edges and at femur-tibia joinings. In leg I, tibia 1 1/2-1 2/3 as long as femur; tarsus 1/2-2/3 as long as tibia. In legs II and III tibia 1 1/4-1 1/3 as long as femur, tarsi ca. 1/3 as long as tibia.

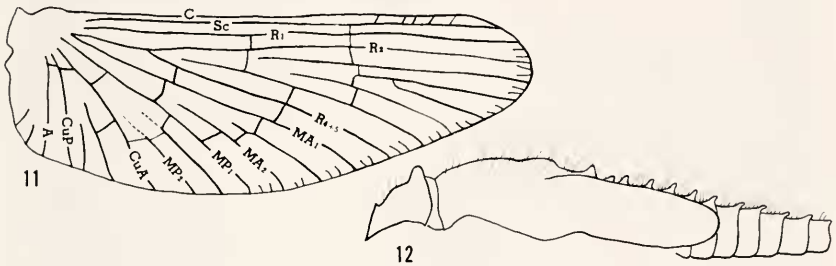
Basal 2/3-3/4 of terga 1-9 chocolate or reddish-brown, apical 1/2-1/3 of each tergum pale; tergum 10 pale brown. Sternum 1 light brown, sterna 2-8 pale, anterior 1/4 of each segment faintly pale brown or reddish-brown; sternum 9 light brown, pale posteromedially. Remnants of nymphal abdominal tubercles evident as faint posteromedian humps on some of terga 2-7. Caudal filaments and basal 1/2 of forceps pale brown; apical half of forceps white. Forceps 3 segmented; basal segment with a blunt projection on inner apical margin; apical segment 3 to 4 times as long as its basal width; styliger plate with a

³With pleasure I name this species after Dr. George F. Edmunds, Jr. who contributed substantially to my overall education as scientist and entomologist.

blunt projection between forceps base, but this may only be distorted tissue, since it is evident on holotype, but not on subimago paratypes.

Male subimago.—Coloration similar to male imago except as follows: mesosternum pale medially except at anterior margin; metasternum pale medially; abdominal sterna 2-6 pale to light grayish-brown; sterna 2-7 with a thin dark brown line at anterior margin; and sterna 7, 8, and basal half of 9 grayish-brown.

Female imago.—Length: body 4.5 mm; wing 5 mm. Coloration and morphology as in male imago except as follows: disc of pro- and mesosternum white; metascutellum with a small, blunt posteromedian hump; all legs similar to legs II and III of male; and rem-



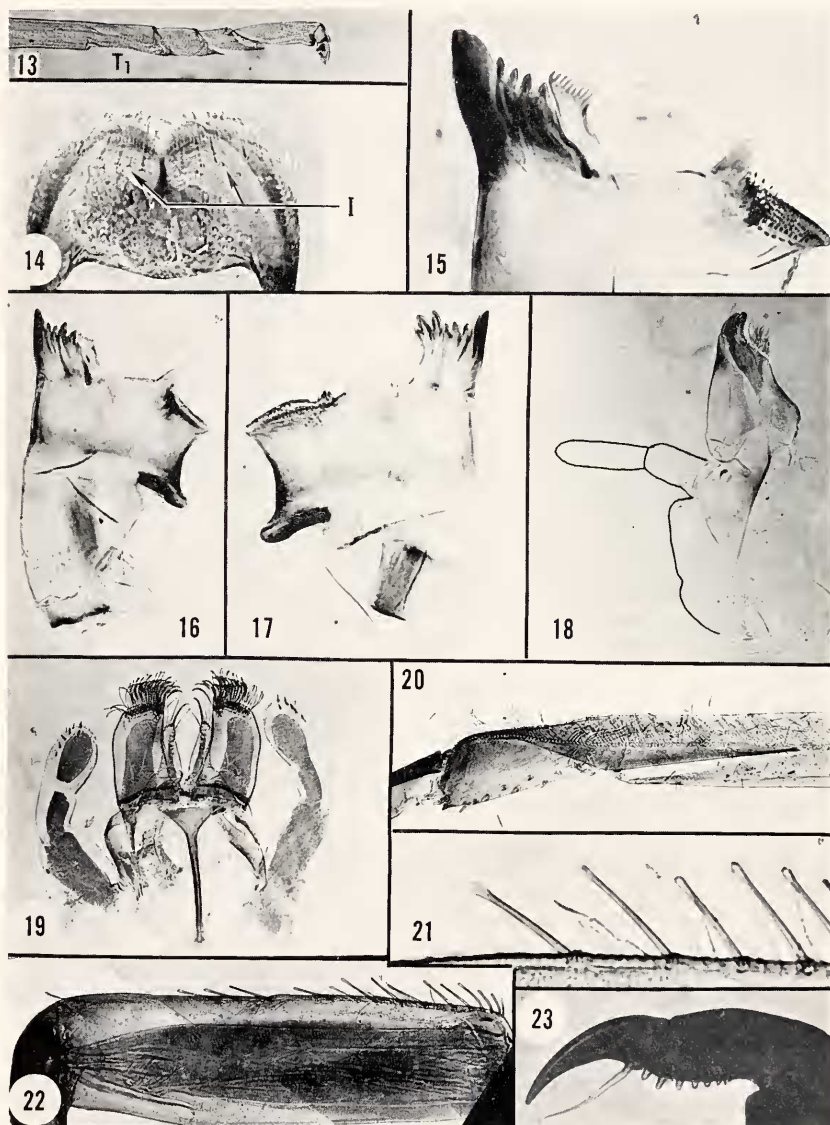
Figures 11-12, *Baetodes edmundsi*, new species. Fig. 11, right forewing, male imago; Fig. 12, outline of nymphal thorax and abdomen, lateral view.

nants of nymphal abdominal tubercles more distinct than in male imago, evident on terga 2-8 as small median humps or very small tubercles.

Female subimago.—Coloration as in female imago, except abdominal sterna similar to those of male subimago.

Nymph.—Length, mature nymph: body 4-5 mm; cerci 4-5 mm. Mouthparts as in Figs. 14-19. Dorsally, labrum (Fig. 14) with 5-8 spinelike setae each side of midline in transverse portion of subapical row; 3 of these setae close to midline, noticeably spaced from laterals. Posterior and sublateral margins of pronotum pale. Posterior margins of pro- and mesonota with a low, rounded, bifid tubercle on midline (Fig. 12). Metanotum brown, posterior margin with a blunt, erect, median tubercle. Thoracic pleurae brown, posterior margins dark reddish-brown on submature nymphs. Thoracic sterna of submatures white; variously colored on matures, usually white except for brown furcatergal pits, but prosternum plus anterior and lateral areas of mesosternum frequently brown. Dorsolateral expansions gradual and extending full length of segment on coxae I and II, abrupt and limited to distal half of segment on coxa III. Coxae with a single, distal, finger-like gill attached to membrane on mesal surface. Femora usually with 7-19 clavate setae on the crest (Figs. 21, 22), occasionally fewer, and almost always an additional pair subapically. Anterior surface of tibiae and tarsi brown, posterior surface white. Claws with 6-9 denticles (Fig. 23).

Terga 1-8 chocolate-brown or slightly dark reddish-brown; lateral and posterior margins, including median tubercles, and tergum 10 pale brown to brown; tergum 9 variable, either with some chocolate-brown coloration basally and brown distally, or else entirely similar to tergum 8 or 10. Terga 1-9 each with a single median blunt tubercle (Fig. 12);



Figures 13-23, *Baetodes edmundsi*, new species. Fig. 13, tarsus and apex of tibia in leg III of male imago (T_1 =tarsal segment 1); Figs. 14-23, nymphal structures. Fig. 14, labrum (I=intermediary spine-like setae); Fig. 15, distal end of right mandible; Fig. 16, right mandible; Fig. 17, left mandible; Fig. 18, left maxilla; Fig. 19, labium; Fig. 20, apical 2/3rd of tibia, leg II; Fig. 21, clavate setae on crest of femur; Fig. 22, femur, leg III; Fig. 23, claw.

tubercles subequal and erect on segments 1 to 4 or 5, but decreasing in height and becoming more posteriorly directed from segments 5 or 6 to 9. Sternum I pale; sterna 2-6 of mature nymph very pale brown medially, white laterally (white areas covered by gills); short, submedian, slightly arcuate, brown streaks near anterior margins on sterna 2-9, and a continuous thin brown line along anterior and lateral margins of 2-6. Brown more profuse on sterna 7-10, leaving only the discal and posterior areas pale. Sterna of submature nymph white, segments 7-10 occasionally with faint brown coloration along pleural fold.

Types.—*Holotype*: male imago, reared from nymph, Verde River, no. of Clarksdale, off state hwy. 89a, Yavapai Co., ARIZONA, collected 6/V/1969, emerged 11/V/1969, R. W. Koss and A. V. Provonsha, in collection of University of Utah (UU), Salt Lake City. *Allotype*: female imago, reared from nymph, same data and deposition as holotype. *Paratopotypes*: 1 male imago with genitalia lost, 4 male subimagos, 2 female imagoes, 4 female subimagos, all reared from nymphs, same data as holotype; 36 nymphs, 9/IV/1968, R. W. Koss and R. W. Baumann, other data as holotype; 58 nymphs, 6/V/1969, other data as holotype. Of these, 3 male and 3 female subimagos, 29 nymphs, UU collection; 1 male imago, 1 male subimago, 2 female imagoes, 1 female subimago, 29 nymphs, R. W. Koss (RWK) collection; and 4 nymphs in each of the following collections: British Museum (Natural History), London; California Academy of Sciences, San Francisco; California State College, Los Angeles; Florida A & M University, Tallahassee; Institute Royal des Sciences Naturelles, Brussels; V. K. Mayo, Tucson, Arizona; I. Müller-Liebenau, Max-Planck-Institut für Limnologie, Plön, Germany; Purdue University, Lafayette, Indiana; and United States National Museum, Washington.

Paratypes: 19 nymphs, Clear Creek, 9 mi e. of Camp Verde, T12 1/2N, R6E, Yavapai Co., ARIZONA, 6/V/1969, R. W. Koss and A. V. Provonsha, 10 specimens, UU collection, 9 specimens RWK collection; 1 nymph, E. Fork of Gila River at state hwy. 527, 40 mi. no. of Silver City, Grant Co., NEW MEXICO, 29/VIII/1969, R. W. & D. T. Koss, RWK collection; 1 nymph, Garner State Park, Rio Frio, TEXAS, 6/III/1936, J. G. Needham, in J. R. Traver collection.

Diagnosis.—The two species differ from each other in the nymphal stage by the characters given in the respective species descriptions, the features in common being presented in a preceding joint description. *B. arizonensis* is darker in overall coloration than in *B. edmundsi*, and the following keys will distinguish nymphs and adults of both species.

Key to North American species of *Baetodes*

Adults

Sterna 2-8 pale, anterior ¼ of each segment faintly pale brown or reddish-brown; femoral disc pale; remnants of nymphal abdominal tubercles evident as faint posteromedian humps on several of terga 2-8. *B. edmundsi*, n. sp.

Sterna 2-8 dark reddish-brown in anterior 1/4-1/3 of each segment, and a nearly full length, somewhat triangular, reddish-brown patch based in each anterolateral corner; femoral disc usually with a longitudinal reddish-brown streak; terga lacking remnants of nymphal abdominal tubercles. *B. arizonensis*, n. sp.

Nymphs

- Middorsal tubercles present on terga 1-9, subequal and erect on segments 1 to 4 or 5 (Fig. 12); a single finger-like gill present ventromesally on each coxa; femoral crests with 7-19 clavate setae, not including subapicals (Fig. 22); claws with 6-9 denticles (Fig. 23); dorsolateral expansion on coxa III abrupt and limited to distal half of segment. *B. edmundsi*, n. sp.
- Middorsal tubercles present on terga 1-6, all tubercles low and posteriorly directed (Fig. 8); coxal gills absent; femoral crests with 3-7 clavate setae (Fig. 9); claws with 9-12 denticles (Fig. 10); dorsolateral expansions gradual and extending full length of segment on all coxae. *B. arizonensis*, n. sp.

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2.0196 *Baetodes*: new species and new records for North America.

Abstract.—Adults and nymphs of *Baetodes arizonensis* Koss, n. sp., and *B. edmundsi* Koss, n. sp. are described. Reared imagoes of the two species permit the first delineation of adult generic features based on a positive association of adults with nymphs. Except for a single specimen recorded from Texas, the genus has not been previously reported as occurring in the United States. *B. arizonensis* is known from central Arizona whereas *B. edmundsi* is known from Arizona, New Mexico, and Texas.—Richard W. Koss, *Department of Geography and Environmental Engineering, The Johns Hopkins University, Baltimore, MD 21218*.

Descriptors: Ephemeroptera; Baetidae; *Baetodes*, new species, Arizona, New Mexico, Texas; terminology.